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Profile of motor abilities of children with cerebral palsy as a predictor of their functional independence in self-care and mobility

Профил моторичких способности деце с церебралном парализом као предиктор њихове функционалне независности у самозбрињавању и мобилности

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Профил моторичких способности деце с церебралном парализом као предиктор њихове функционалне независности у самозбрињавању и мобилности

SUMMARY

Introduction/Objective Limitations of mobility and motor deficits are identified as the predominant in the clinical picture of cerebral palsy.

This research aimed to describe the profile of motor abilities of children with cerebral palsy, which included gross motor, manual and bimanual fine motor functions, and to determine the extent to which their functional independence in self-care and mobility was influenced by the profile of their motor abilities.

Methods A convenience sample of 117 participants with cerebral palsy (56.4% males), aged 7–18 years (M= 13.2, SD = 3.4), was included. The profile of motor abilities consisted of gross motor, manual and bimanual fine motor functions. The Gross Motor Function Classification System – Expanded and Revised, Manual Ability Classification System, Bimanual Fine Motor Function and the Functional Independence Measure – version for Children, were used. Data were analyzed by descriptive statistics and hierarchical multiple regression.

Results More than a half of sample exhibited different levels of gross motor, manual and bimanual function. Lower functional independence in self-care and mobility was associated with higher functional limitations. Manual abilities were the strongest predictor of functional independence in self-care (β = -0.63, p < 0.001), while gross motor functions were the strongest predictor in the mobility domain (β = -0.65, p < 0.001).

Conclusion Improvement of gross motor and manual abilities of children with cerebral palsy is confirmed as one of the basic preconditions for achieving a greater independence and for minimizing or eliminating a need for assistance in mobility and in everyday self-care activities.

Keywords: cerebral palsy; functional performance; mobility; self-care; motor functions

САЖЕТАК

Увод/Циљ Ограничења мобилности и моторички дефицити су идентификовани као преовлађујући у клиничкој слици церебралне парализе.

Циљ истраживања је да се опише профил моторичких способности деце са церебралном парализом, који укључује грубе моторичке, мануелне и бимануелне фине моторичке функције, и да се

утврди у којој мери је њихова функционална независност у самозбрињавању и мобилности под утицајем профила моторичких способности.

Методе Пригодан узорак од 117 испитаника с церебралном парализом (56,4% мушког пола), узраста 7–18 година (M = 13,23, SD = 3,36) је укључен. Профил моторичких способности се састојао од грубих моторичких, мануелних и бимануелних финих моторичких функција. Примењени су *Систем класификације грубих моторичких функција – Проширена и измењена верзија*, *Систем класификације мануелних способности*, *Бимауелне фине моторичке функције* и *Тест функционалне независности за децу*. Подаци су анализирани дескриптивном статистиком и хијерархијском вишеструком регресијом.

Резултати Код више од половине узорка су утврђени различити нивои грубих моторичких, мануелних и бимануелних функција. Нижа функционална независност у самозбрињавању и мобилности је повезана са већим функционалним ограничењима. Мануелне способности су најјачи предиктор функционалне независности у самозбрињавању (β = -0,63, *p* < 0,001), а грубе моторичке функције најјачи предиктор у домену мобилности (β = -0,65, *p* < 0,001).

Закључак Побољшање грубих моторичких и мануалних способности деце са церебралном парализом је потврђено као један од основних предуслова за постизање веће независности и за минимизирање или елиминисање потребе за асистенцијом у мобилности и свакодневним активностима самозбрињавања.

Кључне речи: церебрална парализа; функционално извршавање; мобилност; самозбрињавање; моторичке функције

INTRODUCTION

Motor impairments of varying severity caused by a brain lesion in the early development are dominant in the clinical picture of cerebral palsy (CP)[1]. It is the most common cause of severe physical childhood disability, considered as a physical impairment that affects motor development. The basis of this heterogeneous state is chronic, nonprogressive motor disorder, visible through muscular weakness, limited range of motion, spasticity, pathological reflexes and contractures. Associated and accompanying disorders are frequent, including visual and/or hearing impairment, intellectual disability, epilepsy, speech and behavioral disorders, and secondary musculoskeletal problems [2, 3].

In the daily activities of persons with CP, a number of functional limitations of different severity restrict or even unable their active participation, and participation in society [4]. Depending on the severity of limitations, among other things, children experience difficulties in performing daily and self-care activities [5]. The aforementioned associated and accompanying disorders in the clinical picture of CP have an additional or aggravating effect on the developmental capacity of the child to learn and perform everyday tasks. Consequently, the improvement of functional abilities and the gradual increase of independence in activities of everyday life is undoubtedly one of the key goals of their rehabilitation [6, 7].

The diversity of clinical characteristics makes each case of CP a unique one, constantly posing new challenges in everyday clinical work. An adequate assessment of functional abilities, with an understanding of the importance and impact that these abilities, taken together or individually, have on the everyday life of children from this population, represents the first step in planning the provision of appropriate service support during childhood and in the period of transition from adolescence to adulthood.

One of the frequently asked research questions is related to the relationship between motor abilities and functional status of children with CP. The characteristics of mobility and self-care, including the independence level, are usually examined only in relation to gross motor abilities [8–11] or in relation to gross motor and fine manual abilities [5, 12]. Besides, the effects of different types of treatment were examined [6, 7, 13] and the factors influencing the development of functional independence in children with CP identified [14]. In other words, previous empirical research did not take into account the overall profile of motor abilities of children with CP that, in addition to both gross motor function and manual abilities, includes bimanual fine motor function. Therefore, this research was conducted with the twofold aim: firstly to describe the profile of motor abilities of children with CP aged 7–18 years, and secondly to examine its impact on the level of their functional independence in self-care and mobility. Broadly speaking, the results could be usefull in counseling work with families in a clinical context, in giving a prognosis, as well as for appropriate planning and evaluation of interventions.

METHODS

A convenience sample of 117 participants with CP, 66 (56.4%) boys and 51 (43.6%) girls, was included. The avarage age of participants was 13 years 3 months (SD = 3 years 4 months). The dominant clinical form of CP was spastic, diagnosed in almost two-thirds of the sample, specifically in 77 (65.8%) participants. The most frequent spastic CP was quadriplegia, found in 33 (28.2%) participants. Spastic diplegia was diagnosed in 27 (23.1%), hemiplegia in 17 (14.5%), while the mixed form was noted in 20 (17.1%) participants. Other clinical forms were approximately the same in percentage; ataxic CP was found in eight (6.8%), and dyskinetic/athetoid CP in 12 (10.3%) participants.

The research was conducted in cooperation with health, educational and social welfare institutions, and associations or societies of persons with CP from June 2014 to April 2015 on the territory of 32 municipalities of the Republic of Serbia. The general inclusion criteria were as follows: children of both genders, aged 7–18 years, with CP diagnosed according to the 10th revision of the International Statistical Classification of Diseases and Related Health Problems – ICD-10 [15]. After the informed signed consent was obtained, the data were collected from the available personal medical, educational or psychological records. The study was approved by the Professional Boards of The University of Belgrade (No.61206-2385/2-14).

The profile of motor abilities of each participant contained the data on gross motor, manual and bimanual fine motor functions, with added information about the type of CP. The functional independence level is described as a consistent and usual performance of an activity, while the level of independence is defined according to the level of assistance that children need in order to perform the tasks of everyday life [16].

The Gross Motor Function Classification System – Expanded and Revised (GMFCS–E&R; the abbreviation GMFCS is used as the most common in the literature, with the implied reffering to GMFCS–E&R) [17] determines the level that best represents the child's current gross motor abilities and limitations, based on the assessment of self-initiated movements, meaningful in everyday life, with a special emphasis on sitting, transfer, and mobility. The usual perormance is followed, not what is known that the child can do at its best (capability), as well as the impact of environmental (physical, social, attitudes) and personal factors (motivation, interests, preferences).

The Manual Ability Classification System (MACS) [18] describes how the child uses its hands to handle objects in the activities of daily life. MACS is designed to evaluate the child's self-initiated ability to handle age-appropriate objects, and the need for assistance or adaptation to accomplish everyday life tasks. The assessment is based on a typical performance, without considering the functional differences between the hands, the functioning of each hand separately or explaining the causes of impairment of manual abilities.

The Bimanual Fine Motor Function (BFMF) [4] classifies bimanuel fine motor functions based on the child's ability to catch, hold and handle objects in each hand separately. The possible asymmetry of the upper extremity functions is considered, but the dominant lateralization is not taken into account.

In contemporary disability studies, GMFCS, MACS and BFMF are considered the leading classifications of mobility, fine motor abilities and the level of actual use of the upper extremities. Numerous studies have confirmed the reliability and the overall stability of these instruments, as well as their discriminatory, constructive and predictive validity [4, 18–23]. They are five-level ordinal scales with a higher level indicating a greater functional limitation. MACS and BFMF levels are designed to match GMFCS levels. Taken together, they provide useful information that complete the CP clinical picture [19].

The level of functional independence is assessed by the Functional Independence Measure (FIM), version for children (WeeFIM) [16, 24]. This standardized pediatric instrument for children with acquired or congenital impairments or developmental delays is designed to measure the influence of development strengths and difficulties on the independence at home, school, and in the community, with the aim of identifying priorities in the improvement of functional results and providing support to the family. Three main domains (Self-Care, Mobility, Cognition) are covered with 18 items. The scores are given on a seven-point ordinal scale ranging from 1–Total Assistance to 7–Complete Independence. The total maximum score is 126 (subtotals for Self-Care: 8–56, Mobility and Cognition: 5–35). Each score is obtained by summing points of each task, with a higher score indicating a higher independence level of participants. Psychometric characteristics are reported earlier [16,24,25].

Descriptive statistics and χ^2-test were used to characterize the sample and the outcomes. In order to examine whether the profile of motor abilities, as a set of variables, can predict a significant percentage of variance in Self-Care and Mobility domains, after statistically removing the possible influence of control variables, hierarchical multiple regressions were applied. Taking into account the higher percentage of male participants (56%) and a wide age range (7–18 years), gender and age in months were selected as the control variables. All analyses were performed in SPSS, v.23 (IBM, USA) with the significance level set at $p = 0.05$.

RESULTS

Mild gross motor limitations (GMFCS I–II) are predominant in participants with spastic hemiplegia (70.6%) and ataxia (50.0%). Severe gross motor limitations (GMFCS IV–V) are more frequent in participants with spastic quadriplegia (84.9%) and dyskinetic/athetoid CP (66.6%) than in other clinical forms (Figure 1). These frequencies were significantly different, $\chi^2(20) = 68.15$, $p < 0.001$.

More than a half of our sample exhibited different levels of function measured by GMFCS, MACS and BFMF (Figure 2). For example, the group classified in BFMF level II included participants at all five different GMFCS levels, while the group classified in MACS level V included only participants who performed at the GMFCS levels IV–V. Overlapping of GMFCS and MACS levels are found in 54 (46.2%) participants, and in 61 (52.1%) when considering GMFCS and BFMF levels.

Lower levels of functional independence in both Self-Care and Mobility domains are noted in participants with higher functional limitations measured by GMFCS, MACS and BFMF (Figure 3).

As a control strategy, gender and age were entered in the first block (Step 1) of hierarchical multiple regression (Table 1). The overall model explained only 1% of the total variance in Self-Care domain, without reaching the statistical significance. After the variables of the profile of motor abilities were entered (Step 2), the overall model explained 76% of the total variance. The profile of motor abilities, as a whole, explained an additional 75% of variance, after controlling for gender and age. However, only two variables made a unique contribution, with the MACS level having a higher standardized coefficient (β = -0.63, $p < 0.001$) than the GMFCS level (β = -0.30, $p < 0.01$). With each increasing of limitations in manual abilities (MACS), there is a decrease in the level of functional independence in self-care by 7.41 points, or by 3.46 points when it comes to limitations in gross motor function (GMFCS). Neither gender, age nor BFMF level made a unique contribution as predictors.

Only partially comparable results were obtained when predicting of functional independence in Mobility domain was examined (Table 1). Gender and age together explained only 4% of the total variance of mobility, without statistical significance (Step 1). When the profile of motor abilities was entered (Step 2), the overall model explained 77% of the total variance. Accordingly, the profile of motor abilities, as a whole, explained an additional 73%, after controlling for gender and age. Similar to the previous analysis, only two motor abilities made a unique contribution, with the GMFCS level having a higher standardized coefficient (β = -0.65, $p < 0.001$) than the MACS level (β = -0.35, $p < 0.001$). Therefore, increasing of the gross motor limitations (GMFCS) causes a decline of the functional independence in mobility by 5.28 points. When considering the unique influence of manual abilities (MACS), in this model, with their reducing, there is a decline of the functional independence in mobility by 2.75 points.

DISCUSSION

The research results confirmed a strong association between the functional independence in self-care and mobility and the motor abilities of participants with CP. As functional limitations in the domains of gross motor, manual and bimanual fine functions increase, the functional independence in self-care and mobility decrease, and vice versa. In the case of self-care, hierarchical multiple regression showed that manual abilities of participants with CP, measured by the MACS, explained the most of its variance. Contrarily, most of the variance of mobility was explained by the gross motor function, measured by the GMFCS.

The variations in the dimension of mobility largely explained the relationship between GMFCS and level of disability [26]. Specifically, the severity of present gross motor disability was singled out as a strong indicator of the level of disability in the domains of physical independence, mobility, occupation and social integration [26]. Later, the secondary analysis confirmed that GMFCS level was the most significant predictor of restriction in mobility, with BFMF and IQ as significantly contributing variables [4]. Intellectual level, often referred to as the educational level or cognitive functional level, is one of the personal features listed as possible factors determining the functional independence of persons with CP [14]. This may be caused by the association between the number of additional neuroimpairments in the individual child, including the cognitive impairments, and CP type and GMFCS level, as a result of major brain malformations and/or severe compromise at birth [4, 27]. Moreover, a decrease in the need for assistance in everyday activities is associated with the improvement of gross motor functions after a five-month functional goal-directed therapy (physical therapy with the emphasis on exercising of functional activities) [7]. After all, the need for caregiver assistance was strongly related to GMFCS level and accomplishment of activities [10].

Next, functional difficulties in different domains of everydaily functioning are more common in children with CP who are classified in GMFC IV–V. In one study, it was shown that daily living skills were statistically significantly different among school-aged children with CP compared to their gross motor functions [11]. Functional limitations in daily living skills were more likely for children in GMFCS IV–V (wheelchair needs) in comparison to children in GMFCS I (walking) and GMFCS II–III (restricted ambulation).

Comparable results were obtained on a sample of younger children with CP aged 2 years – 7 years 6 months [10]. As the strongest overall predictor, gross motor limitations, classified according to the GMFCS, explained 84% of the variance in mobility, or 82% and 63% of the variance in caregiver assistance, and modification nedded. Mobility was also a significant contributory factor in self-care and some aspects of social functioning [10].

Furthermore, our findings are close to those reported in other studies when analyzing the relationship between GMFCS and MACS levels and mobility and self-care activities of children with CP [5, 9]. Generally, limitations in self-care increased progressively with MACS level [5].

Considering here confirmed overlapping of GMFCS and MACS levels in almost half of our sample, it can be concluded that GMFCS and MACS classifications are mutually complementary to each other in determining of the functional limitations. In particular, data on the overlapping of GMFCS and MACS levels in 46% of our sample is in accordance with the previous empirical findings according to which the complete agreement is seen in 49% of participants [18]. An absolute agreement of 39.2% was found on a sample of 222 participants aged 2–17 years [28]. Next, an agreement of 77% was calucated between MACS and BFMF levels [23].

In other words, when considering functional and motor profile of a person with CP, the data on GMFCS and MACS levels are mutually complementary, and are not to be used as an equivalent in the clinical practice. This outcome of the analysis is consistent with previous theoretical and empirical findings; GMFCS and MACS are two distinct classification systems that are constructed on different conceptual bases. Therefore, the influence that gross motor functioning has on manual function and their interrelation are possible explanations of our findings [29]. Namely, while GMFCS is simpler and more focused on basic motor patterns (head control, sitting, ambulation, transfers), MACS includes a complex motor-cognitive dimension of manual abilities because the functions of upper extremities are closely related to cognitive abilities and voluntary motor control [17–19]. Specifically, one of the key components of performing self-care activities are manual skills [10]. Additionally, the relationship between the MACS scale and the BFMF scale can be described similarly, bearing in mind that these two systems describe close, but different aspects of the function of the upper extremities. More precisely, the MACS is more focused on the evaluation of *activity*, while the BFMF is based on the assessment of the level of *impairment* and the level of *capacity* [4].

It is necessary to have a closer look at the finding that there was no statistical significance for BFMF as a predictor. Individually, changes in BFMF levels are at least reflecting on the level of functional independence in both mobility and self-care domain, as well. This can be explained by the findings of a study conducted on a sample of 185 children with spastic CP in which the association of GMFCS and MACS was confirmed, with the highest correlation coefficient in the subgroup of children with quadriplegia and the lowest in the subgroup of children with hemiplegia [12]. Moreover, this finding is a reflection of the consequences that impairment of the muscles of trunk, upper and lower extremities, as well as the greater presence of cognitive problems have on the clinical picture of quadriplegia. As a result, there is an association of gross motor abilities of the child and his ability to handle objects in daily life. Contrarily, the assumed asymmetry in the clinical picture of hemiplegia leaves the possibility that the child can handle objects by using unaffected or less affected hand [12]. The need to make a clearer differentiation between the capacity of fine motor abilities and normal manual performance in children with unilateral spastic CP and the clinical significance for treatment planning and evaluation of outcomes can be read in previous reports [23].

Besides, when compared in relation to the terminology and definitions given in the International Classification of Functioning, Disability and Health – ICF [30], it can be seen that the BFMF classification relies more on the determination of capability as "executing tasks in a standard environment" (what a child *can do* in a controlled environment). However, the MACS classification is based on the assessment of *performance* as "executing tasks in the current environment (what a child *really does* in everyday settings) [8]. Further, since the BFMF is more based on the assessment of the symmetry of the upper extremities function, from the aspect of the present *impairment*, it can be concluded that its predictive power is limited when determining functional independence in self-care and movement. Applied together, these classifications can provide complementary information on the difference between the fine motor capacities (measured by the BFMF) and the actual use of the upper extremities in daily life (measured by the MACS). By assessing those motor functions that are meaningful in everyday life based on the usual achievements in the home, school and community, the functional independence of a child with CP in the activities of daily life can be determined to a considerable extent, regardless of the lateralization of motor impairment.

CONCLUSION

Based on the presented results, gross motor abilities of children with CP determine to a large extent the level of their functional independence in mobility. At the same time, the level of functional independence in self-care is largely determined by manual abilities. Therefore, it can be concluded that the improvement of gross motor and manual abilities is one of the basic preconditions for achieving greater independence for children from this population, that is, for minimizing or eliminating the need for assistance in mobility and in everyday self-care activities. Developing the independence of children with CP largely relies on increasing or improving of level of development of gross motor and manual abilities. Finally, although the symmetry of the function of upper extremities does not determine statistically the level of functional independence in the examined domains, the data on developmental level of fine bimanual functions complement the data that make the profile of motor abilities of children with CP.

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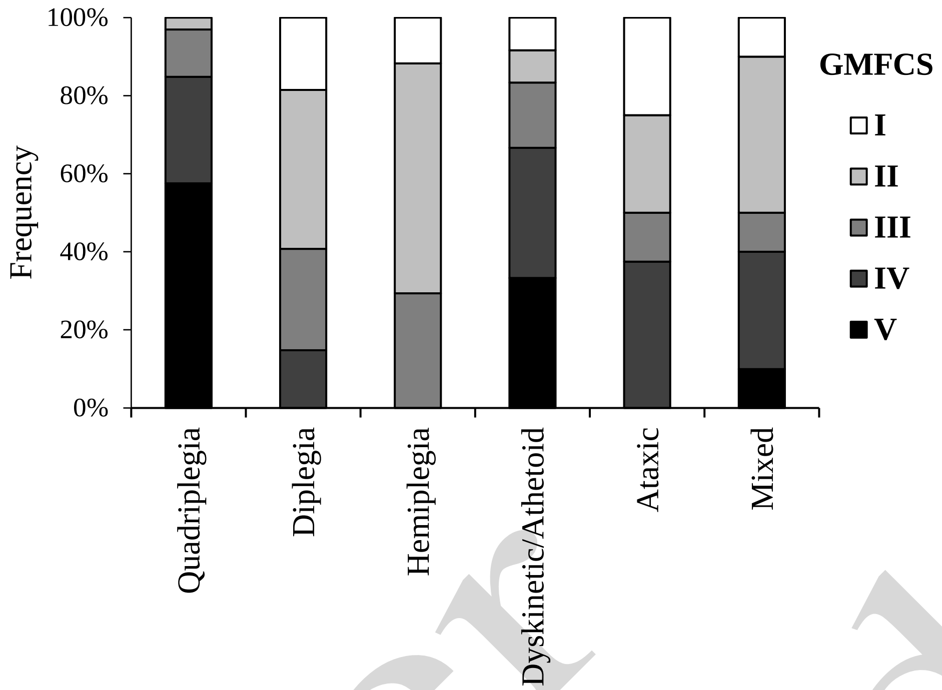

Figure 1. Distribution of gross motor function (GMFCS) in relation to cerebral palsy type

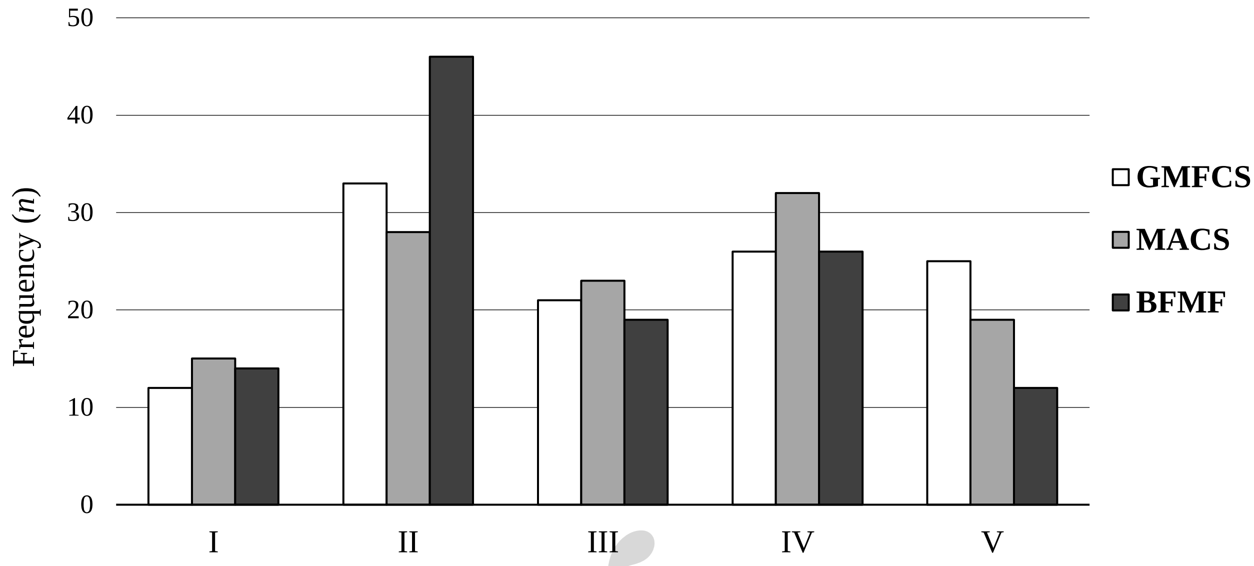

Figure 2. Profile of motor abilities of participants with cerebral palsy – distribution of gross motor (GMFCS), manual (MACS) and bimanual fine motor functions (BFMF)

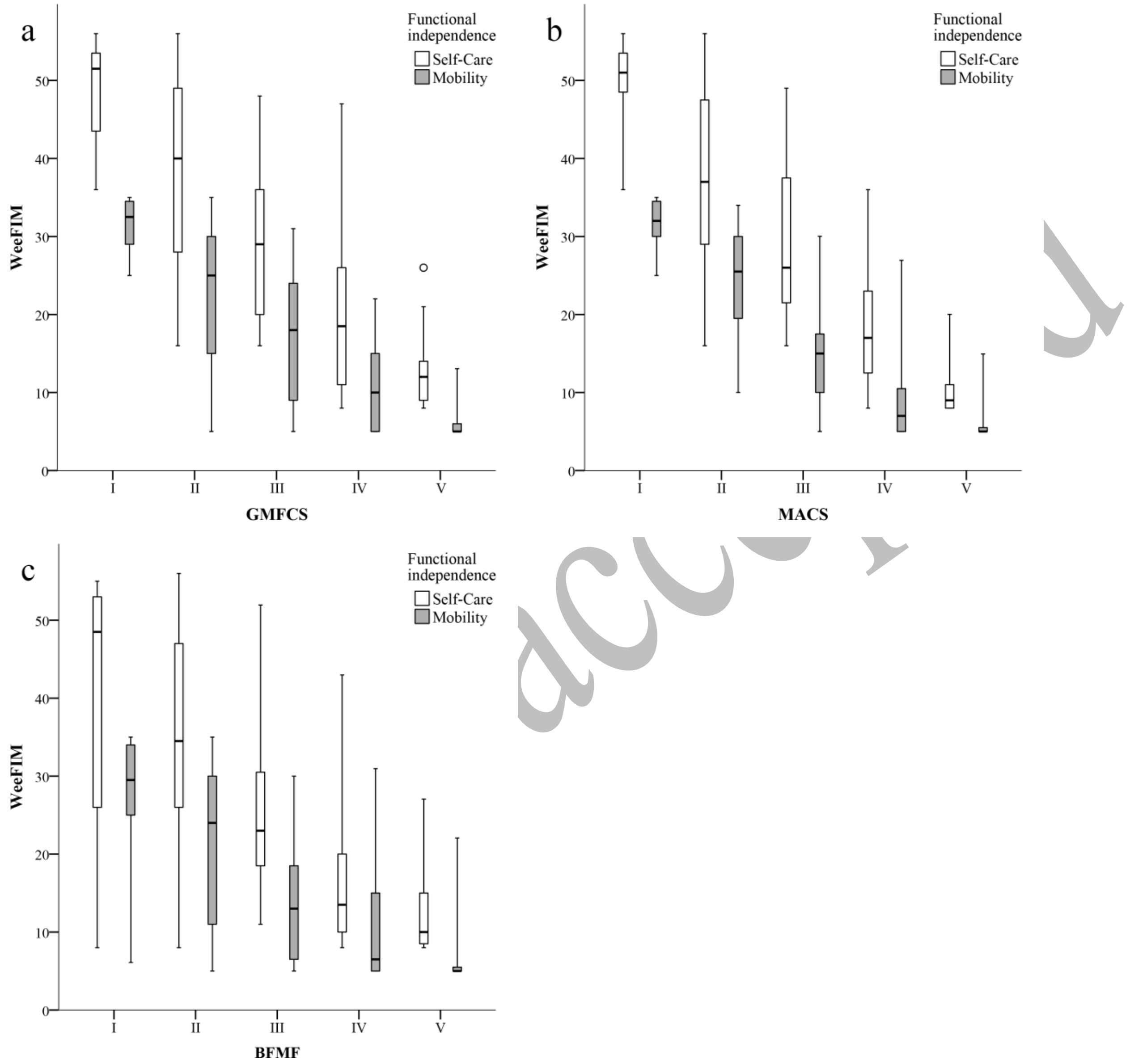

Figure 3. The level of functional independence of participants with cerebral palsy in self-care and mobility domains in relation to the level of: a) gross motor (GMFCS), b) manual (MACS) and c) bimanual fine motor functions (BFMF)

Table 1. Prediction of the functional independence of participants with cerebral palsy in self-care and mobility based on the profile of motor abilities – results of hierarchical multiple regression

Predictor/Model		Step 1				Step 2			
		B	SE (B)	β	t	B	SE (B)	β	t
Self-care	Gender[a]	2.84	2.92	0.09	0.97	1.55	1.46	0.05	1.07
	Age[a]	0.01	0.04	0.02	0.20	0.03	0.02	0.08	1.58
	GMFCS					-3.46	1.04	-0.30	-3.34*
	MACS					-7.41	0.83	-0.63	-8.94**
	BFMF					0.25	0.97	0.02	0.26
	R^2	0.01				0.76			
	Adj.R^2	0.00				0.75			
	ΔR^2	0.01				0.75**			
	F (df1, df2)	0.47 (2, 114)				70.19 (5, 111)**			
Mobility	Gender[a]	2.86	2.01	0.13	1.42	2.00	1.00	0.09	2.00
	Age[a]	-0.03	0.02	-0.11	-1.13	-0.01	0.01	-0.05	-1.11
	GMFCS					-5.28	0.57	-0.65	-9.28**
	MACS					-2.75	0.71	-0.35	-3.86**
	BFMF					0.91	0.66	0.10	1.37
	R^2	0.04				0.77			
	Adj.R^2	0.02				0.76			
	ΔR^2	0.04				0.73**			
	F (df1, df2)	2.15 (2, 114)				73.86 (5, 111)**			

B – unstandardized beta coefficient; β – standardized coefficient; R^2 – coefficient of determination; Adj.R^2 – adjusted coefficient of determination; ΔR^2 – multiple correlation coefficient change;

[a]control variables;

*$p < 0.01$;

**$p < 0.001$

